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15.2 Manual and Mechanical Material Handling

(Formerly H&SM Chapter 29)

Recommended for approval by the ES&H Working Group

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New document or new requirements

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15.2

Manual and Mechanical Material Handling*

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* **Minor revision**

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Manual and Mechanical Material Handling

1.0 Introduction

Material handling is a task that almost every worker performs, either as a one-time or infrequent duty or as part of regular work. Material handling encompasses a wide range of work activities—from occasional movement of very large loads with cranes and powered industrial trucks to routine, repetitive lifting of relatively light objects and tasks that are incidental to a worker's regular, daily activities, such as an office move.

This document contains specific requirements and general guidance to protect workers from injuries when performing manual and mechanical material-handling activities. These requirements and guidance are based on the sources listed in Sections 5.0 and 6.3 and apply to all material-handling activities performed at the Laboratory. Additional information can be found in Document 19.1, "LLNL Ergonomics Program," in the *Environment, Safety, and Health (ES&H) Manual.*

2.0 Hazards

The hazards associated with improper material handling include being struck by a load, losing control of a load, physically overexerting oneself, and exceeding equipment capacities. Such accidents can lead to injuries (e.g., abrasions, bruises, and broken bones) and even loss of life. Material-handling accidents account for a sizable percentage of all occupational injuries that occur in every work area throughout the Laboratory—not just in stockrooms or warehouses. The risk of injury is not confined to manual lifting of heavy objects. Some lost-time injuries have occurred in office situations where lifting is infrequent and involves only small items.

3.0 Controls for Protection Against Injury

3.1 Work Planning

The likelihood of injuries significantly increases when lifting or moving bulky, heavy objects that cannot be held close to the body. Injuries can also occur when conducting repetitive lifts of lighter objects over long periods of time. Accidents and injuries related to material handling may occur when a worker performs a task without the required assistance or because of inadequate worker training, poor judgment, or poor selection or improper use or maintenance of equipment.

Therefore, supervisors and workers should perform an appropriate analysis to determine the proper technique or lifting device required for all material-handling activities. As part of the analysis, consider whether a worker is able to carry out the materials-handling task in question, even with assistance. In addition, consider the following other factors:

- Container characteristics
  - — Weight, length, width, height, and depth.
  - — Center of gravity (i.e., weight distribution within container).
  - — Handles, texture, and grasp point.
  - — Stability (particularly in the case of liquids and bulky items).
- Workplace configuration
  - — Height of lifts.
  - — Carrying distance and direction changes.
  - — Obstacles (e.g., stairs and slopes).
  - — Traction on working surfaces (i.e., observe whether surfaces are slippery, smooth, or rough).
- Task characteristics
  - — Forward reach.
  - — Duration, frequency, and pace.
  - — Temperature, lighting, and humidity.
  - — Work organization (e.g., teamwork, time pressure, and the availability of help).
- Mechanical lifting devices
  - — Weight demand and equipment limitations (i.e., load limit).
  - — Accessibility requirements.
  - — Worker experience.
  - — Maintenance status.

Supervisors are encouraged to use a team approach by rotating people who constantly perform material-handling tasks to a lighter job after 1–2 hr of continuous effort.

3.2 Worker Training and Qualification

LLNL requires workers to be properly trained and physically capable for any work assignment that involves the lifting of heavy objects or the repetitive lifting of lighter objects over long periods. Even for incidental material-handling activities, consideration should be given to a worker's ability to perform a task. Therefore, a work supervisor shall determine if there are potential issues (e.g., physical ability or training) that need to be evaluated before assigning workers to perform material-handling tasks.

Training

Workers shall be properly trained in correct lifting techniques and in the use of powered and mechanical material-handling equipment, such as lifts, hoists, powered industrial trucks (such as a fork truck), and cranes. The Hazards Control Department offers a back care workshop, which covers proper and safe techniques for lifting and handling heavy objects, as well as an exercise program to strengthen the back. The Health Services Department offers customized training courses for groups or individuals and provides recommendations for whole-office moves. Formal training may also be supplemented with on-the-job training; the ES&H Team and the Health Services Department can provide assistance.

The courses listed below are offered by the Hazards Control Department. Refer to the list of courses online (https://www-ais.llnl.gov/llnl_only/docs/hr/catalog/) for additional details.

- HS5300, "Back Care Workshop"—Available to all employees.
- HS5620-CBT, "Powered Industrial Truck (PIT) Safety"—Required for operators of powered industrial trucks.
- HS5620-LIC, "Powered Industrial Truck (PIT) Operators License"—Required for operators of powered industrial trucks.
- HS5690, "Incidental Crane Safety"—Required for operators of cranes or hoists and rigging to lift 900 kg (2000 lb) or less.
- HS5700, "Intermediate Crane Safety"—Required for operators of cranes or hoists and rigging to lift more than 900 kg (2000 lb).

The Health Services Department offers the following courses:

- OH1003, "Healthy Backs."
- OH8002, "Back Injury Prevention."
- OH8003, "Preventing Back Injuries During Office Moves."

Contact either the Hazards Control Department or the Health Services Department, as necessary, for training on specialized material-handling issues.

Physical Qualification

Workers need to be physically qualified to perform tasks requiring lifting of heavy objects, repetitive lifting of modest-weight objects, or lifting of lighter objects outside of a normal work routine, (e.g., moving office supplies and furniture). Work supervisors shall ensure worker qualification, as specified in Section 4.1.

For each task, workers and their work supervisor should jointly review planned activities to determine the appropriate method (e.g., job redesign or the use of a lifting device) for reducing the risk of injury.

3.3 Personal Protective Equipment

A work supervisor shall evaluate job assignments to determine the need for safety-toed shoes, gloves, and other types of personal protective equipment (PPE). The Hazards Control Department can assist in determining the appropriate type of PPE for a task. In all cases, selection of PPE must be documented in a safety plan or Hazard Assessment and Control (HAC) Form. Additional PPE information and requirements can be found in Document 11.1, "Personal Protective Equipment," in the *ES&H Manual*.

Back belts may help reduce the risk of injury when properly used in combination with a back care training program, ongoing evaluations of lifting and material-handling techniques, and continuous supervision. The Health Services Department and the Hazards Control Department recommend introducing such equipment only after conducting a thorough task analysis and developing a comprehensive plan for periodically monitoring proper use. Contact your ES&H Team for assistance and further information.

3.4 Precautions for Safely Lifting and Handling Materials

When lifting or handling materials manually, use only methods that ensure your safety and that of the material. Never attempt to lift objects that are too heavy or bulky to handle safely. Never overestimate your ability to perform a task. Whenever possible, push rather than pull loads: Pushing uses the strong leg muscles, whereas pulling uses the easily strained back muscles.

When occasional lifts of compact loads [<70 kg (154 lb)] are required, observe the following precautions:

- Loads should be handled no more than 18 cm (7 in.) in front of the body as measured from the ankles. The heavier a load, the more closely to the body the load should be held.
- Very low lifts [25 cm (10 in.) or less from the floor] are not desirable because of the difficulty of maintaining balance when squatting to lift.
- Medium lifts [75–135 cm (30–54 in.) from the floor] are more desirable because more strength is available in the lower part of this height range.
- High lifts [135–188 cm (54–75 in.) from the floor] are not recommended, except when the item to lift weighs less than 5 kg (11 lb).

Muscle fatigue can potentially occur where lifting is required more than once every 2–5 min. Therefore, the weight for repetitive lifts should be less than that for occasional lifts. If the lifting rate exceeds six lifts per minute, lifting should be limited to 20 min or less to allow for muscle recovery. Moving objects by sliding, rather than lifting, is recommended for repetitive handling tasks.

For ease of manipulation during subsequent moves, heavy items should be stored on racks, shelves, or the like at elbow level. Lighter items may be stored at either higher or lower levels.

3.5 Safe Lifting Practices

The following are recommended safe practices for lifting and moving heavy objects:

- Provide good handholds on an object to be carried.
- Firmly grip an object to be carried.
- Use carts and handling aids to support an object's weight.
- Try to minimize the distance that an object is moved.
- Carry a load close to your body and at a proper height from the floor. When standing, avoid lifting an item to a height greater than 50 cm (20 in.) or lowering an item to a height less than 20 cm (8 in.).
- Push or pull objects whenever possible, rather than lifting or lowering objects.
- Position storage materials on racks or shelves in ways that make handling easier (e.g., place the heaviest objects at elbow height).
- Keep your torso in a neutral, upright position whenever possible when lifting a heavy load. The neutral position is 0–15°. An angle greater than 15° is considered high risk.
- Do not twist or bend while lifting or handling a heavy load.
- Do not using jerking motions to move a load.
- Provide elbow support for long reaches.
- Warm up before starting a strenuous task after a less-strenuous task (e.g., changing from sitting to performing a rapid, dynamic task).
- Avoid lowering materials that need to be later lifted.
- Plan movements of material in direct paths (i.e., do not zigzag or backtrack).
- Avoid using stairs when handling heavy objects. As a general rule, if the use of stairs is unavoidable, keep one hand free to grasp the rail quickly to prevent falling.

- Use an adjustable/tiltable table or a reach extender to reduce forward bending or extended reaches.
- Use a step stool or low platform to reduce back hyperextension.
- Use roller bearings or roller conveyors to reduce twisting.
- Use sheet supporters (see Fig. 1), hand trucks, and small overhead hoists to improve posture.

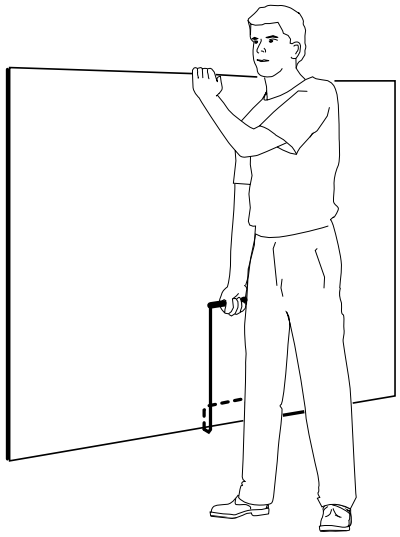


Figure 1. Sheet supporter.

3.6 Pre-Lift Inspections and Considerations

Contact your area ES&H Team industrial safety engineer or the Health Services Department representative for assistance with, or information on, the following:

- Material-handling task hazard analyses.
- Lifting techniques.
- Mechanical aids.
- Methods for determining general weight-limit guidelines.
- A worker's ability to perform a task.

Your ES&H Team industrial safety engineer can also determine the acceptability of certain manual lifts using an equation in *Work Practices Guide for Manual Lifting* [an excellent guide published by the National Institute for Occupational Safety and Health (NIOSH)]. The equation applies to two-hand, symmetrical, repetitive lifting situations in which the load is held in front of the body, without twisting of the torso. The equation, although not applicable to all situations, may be useful in many instances as an initial screening tool in determining if a lifting task is even safe to consider.

Before lifting a heavy object:

- Inspect the load for sharp edges, slivers, and wet or greasy spots.
- Wear gloves (and, if necessary, a long-sleeved shirt) when lifting or handling objects with sharp or splintered edges. To ensure a good grip on the object, make sure the gloves are free of oil, grease, or other slippery materials.
- Inspect the route over which the load is to be carried. The route should be free of obstruction or spills that could cause tripping or slipping.
- Consider the distance over which the load is to be carried. Gripping power may weaken over long distances.
- Size up the load, and make a preliminary lift to be sure the load is within your capacity. If the load is beyond your capability, get help or use a mechanical lifting device.

3.7 Techniques for Moving and Lifting Material

In addition to following the precautions in Section 3.6, use the techniques below when moving or lifting heavy materials.

Two-Hand Squat Lift

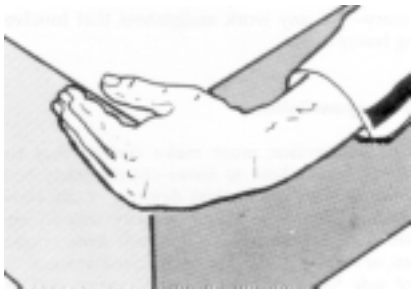
Lifting is a part of many everyday jobs but is often done improperly, resulting in pulled muscles, disc lesions, and other injuries. Figure 2 demonstrates a two-hand squat lift using six good lifting techniques that have been adapted from the National Safety Council.

Assisted One-Hand Lift

The assisted one-hand lift (see Fig. 3) is a safe method for lifting objects from containers and is also a viable lifting alternative when the two-handed squat lift cannot be used. For a good assisted one-hand lift, follow the three steps below:

1. Place the nonlifting hand on top of the container, bend over the container, and assume the lift position.
2. Reach and grasp the object to be lifted.
3. With the nonlifting hand, push down on the container top, raising the upper body to a vertical position. Be sure to let the nonlifting hand, not your back, do the work.

Step 1. Make sure your feet are firmly placed about 24–40 cm (10–15 in.) apart. Place one foot alongside the object being lifted and the other behind it.



Step 2. Grasp the object using the palmer grip—the fingers and the hand should be extended around the object to be lifted using the full palm.

Step 3. Using the knee-bend or squatting position, keep the back straight. Tuck in the chin so the neck and head continue the straight back line.

Step 4. Tuck arms and elbows into the side of the body and position the body so that your weight is centered.

Step 5. Start lifting with a thrust of the rear foot, keeping the object close to your body as you lift with your legs—not with your back.

Step 6. Carry the load close to your body—not on extended arms. To turn or change your position, shift your feet. Do not twist your back.

Figure 2. Proper techniques for manually lifting materials.

Assisted one-hand lifts assume that the object to be lifted can be grasped with one hand and that the duration of the lift is not so long that the object becomes awkward to handle. In general, loads weighing 7–9 kg (15–20 lb) would not be excessive for most workers.

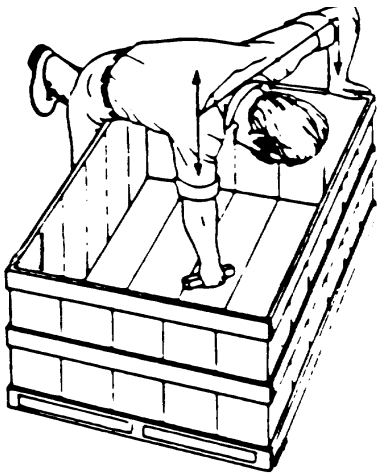


Figure 3. Assisted one-hand lift.

Team Lifts

Two or more workers transporting a large load should adjust the load to ride level and so that each person carries equal weight. Long objects (e.g., pipe or lumber) should be carried on the same shoulder, and the workers should walk in step. Shoulder pads should be used to prevent shoulder injuries (e.g., cuts) and to help reduce fatigue.

When team lifting is required, make sure that the individuals involved are similar in size and physique. One person should act as the leader and give commands on when to lift or lower the object.

Other Lifting Techniques

When handling the types of materials below, follow the guidelines given.

Boxes and Cartons. The best way to lift a box or carton is to grasp opposite top and bottom corners. Large and bulky items shall be handled by more than one person.

Sacks. Sacked materials should be grasped at opposite corners. Upon reaching an erect position, a worker should let the sack rest against the hip or stomach, then lift the sack onto his/her shoulder. Avoid using swinging or jerking motions to raise the sack to the shoulder. A worker should not attempt to move a sack that he/she cannot lift and place onto his/her shoulder or, preferably, "hug" (i.e., hold to the chest).

Irregular Objects. Irregular objects present special problems. Some items (e.g., televisions and computer monitors) have a regular shape but an irregular weight distribution. Often, it is necessary to turn such objects over or up on end to obtain the best possible grip. Any worker who is unable to handle an object, because of either the object's weight or shape, shall request assistance.

Long Objects. Long pieces of pipes, bar stock, or lumber should be carried on the shoulder. A second person should be used as a guide when going around corners. In addition, shoulder pads should be used to prevent shoulder injuries (e.g., cuts) and to help reduce fatigue.

Sheet Metal. Sheet metal usually has sharp edges and corners and should be handled with the appropriate gloves.

3.8 Packing and Crating

Personnel in the Shipping Department typically pack and crate materials for offsite shipment. However, for programmatic purposes (e.g., when shipping environmentally sensitive specimens in dry ice), program personnel may be permitted to perform such activities. In such cases, the Shipping Department shall be consulted for guidance regarding material-handling and transportation safety requirements.

3.9 Mechanical Lifting Devices

Mechanical lifting devices (rather than manual effort) should be used to lift and move objects whenever practical. The type of equipment used, however, shall be appropriate for the task. Workers are always encouraged to use mechanical equipment to lift heavy or bulky objects. Various types of mechanical lifting devices are described below.

Hand Trucks, Dollies, and Wheelbarrows

Many special types of hand trucks, dollies, and wheelbarrows are available. The type of equipment most suitable for a task should be used. For instance, a handcart (see Fig. 4) designed to move liquefied gases also can be used to move cryogenic vessels. (Note that a hand truck is not appropriate for handling all types of materials.) When working with mechanical lifting devices, workers should wear gloves and safety shoes to reduce hazards to the hands, toes, and feet. Equipment that is not in use should be stored in a designated area, not parked in aisles or other places where the equipment would create a tripping hazard or traffic obstruction.

Figure 4. Cryogenic handcart.

Two-wheeled trucks (Fig. 5) may appear easy to handle, but the procedures and precautions below shall be followed to ensure safety.

- To place a load onto a two-wheeled truck, tip the load slightly forward so that the tongue of the truck can be easily slid under the load.
- Keep the load's center of gravity as low as possible. Place heavy objects under light ones.
- Position the load so that it does not slip, shift, or fall. If possible, stack objects only to a height that allows a clear view ahead.
- Let the truck carry the load. The operator should only balance and push.
- Avoid walking backwards with a hand truck.
- Secure bulky or pressurized items (e.g., gas cylinders) to the hand truck.

Figure 5. Common two-wheeled hand truck.

- When going down an incline, keep the truck ahead so that it can be observed at all times.
- Move the truck at safe speeds. Do not run. Keep the truck constantly under control.

Pallet Jacks

Before using a jack (Fig. 6) for lifting, check the manufacturer's capacity plate or stenciled capacity to make sure the jack can support the load. Jacks shall be visually inspected before each use. Any sign of hydraulic fluid leakage is sufficient reason to remove a jack from use. The surface on which a jack is used shall be level.

Figure 6. Pallet jack.

Crowbars

The principal hazard associated with crowbars (Fig. 7) is slippage. A dull or broken crowbar is more likely to cause injury than a sharp one. The point or edge of a crowbar should have a good bite. During material handling with a crowbar, workers should be positioned to avoid falls or pinched hands if the crowbar slips. When not in use, crowbars should be stored to avoid a trip/fall hazard.

Figure 7. Crowbar.

3.10 Powered Lifting Devices

Powered mechanical devices shall be used for lifting and moving objects that are too heavy or bulky for safe manual handling. However, only workers who are properly trained and qualified are permitted to operate such equipment. Heavy objects that require special handling or rigging shall be moved only by qualified riggers or under the guidance of workers specifically trained for such tasks. The Hazards Control Department conducts training programs and licenses workers who demonstrate the

ability to operate powered industrial trucks (e.g., fork trucks), cranes, and hoists in a safe manner. (Powered industrial trucks are defined as mobile, power-driven vehicles used to carry, push, pull, lift, stack, or tier material.)

All materials that are loaded onto trucks for over-the-road use shall be firmly secured to the truck using rope, nylon strap, chain, or other suitable equipment to prevent shifting during transit. Chapter 10 of *DOE Hoisting and Rigging Standard* (DOE-STD-1090-99) contains the safety precautions to be taken when powered industrial trucks are used to load trailers.

Detailed information on the safe operation of power-operated cranes/hoists and powered industrial trucks can be found in Document 15.3, "Crane and Hoist Safety," and Document 15.4, "Powered Industrial Truck Safety," in the *ES&H Manual*.

Maintenance

All mechanical lifting and moving devices shall be inspected periodically and repaired as necessary. Under no circumstances shall defective equipment be used. All lifting equipment shall list its rated load capacity, which operators shall not exceed. As a safety precaution, check for faulty or defective parts before lifting a load that is near the load capacity of the equipment.

4.0 Responsibilities

General responsibilities for all workers are described in Document 2.1, "Laboratory and ES&H Policies, General Worker Responsibilities, and Integrated Safety Management," in the *ES&H Manual*. Specific responsibilities for work involving heavy lifting and powered industrial trucks are listed under each title below.

4.1 Supervisors

- Evaluate job assignments, and consider ways to redesign tasks to reduce or eliminate material-handling hazards.
- Determine the proper technique or lifting device required and the necessary PPE for material-handling activities. (When PPE is required, the selection shall be documented in accordance with Document 11.1.)
- Enforce the use of safe lifting techniques.
- Ensure that
    - Workers know how to manually move objects in a safe manner.

  - — Workers who routinely lift heavy objects are evaluated by the Health Services Department prior to initial work assignment.
  - — Only trained and licensed personnel operate powered industrial trucks, cranes, or hoists.
- Ensure that large or heavy objects are moved mechanically and that material-handling equipment is kept in good mechanical condition.

4.2 Workers

- Never lift or move objects that exceed your physical limitations.
- Observe all established safety requirements, and exercise good judgment when lifting or moving heavy objects.
- Use appropriate mechanical devices when handling materials.
- Obtain and maintain the required licenses to operate cranes, hoists, and powered industrial trucks.

4.3 Hazards Control Department

- Assist supervisors and workers with material-handling issues (e.g., task and hazard analyses).
- Provide formal and informal training courses.

4.4 Health Services Department

- Evaluate a worker's physical ability to perform work that requires heavy or repetitive lifting.
- Issue work restrictions, as necessary.
- Provide ergonomic assessments of complex work situations. Ergonomic assessment includes assisting workers in returning to work after injury-related leave or restricted duty.
- Conduct formal and informal training.

5.0 Work Standards

29 CFR 1910, Subpart I, "Personal Protective Equipment."

29 CFR 1910, Subpart N, "Material Handling and Storage."

29 CFR 1926, Subpart E, " Personal protective Equipment and Life Saving Equipment."

29 CFR 1926, Subpart H, " Materials Handling, Storage, Use, and Disposal."

29 CFR 1926, Subpart N, " Cranes, Derricks, Hoists, Elevators, and Conveyors."

UCRL-AR-129931, *LLNL Ergonomics Standard*.

Department of Energy, *DOE Hoisting and Rigging Standard*, DOE-STD-1090-99, March 1, 1999.

Public Law 91-596, OSHA Act of 1970, Section 5(a)(1).

6.0 Resources for More Information

6.1 LLNL Contacts

Contact the individuals or organizations listed below if you have questions about material-handling issues.

- Worker's supervisor—General lifting concerns.
- ES&H Team industrial safety engineer—Specific concerns about lifting safety.
- Safety Programs Division—Institutional concerns.
- Hazards Control Department, Education and Training Division—Training.
- Health Services Department—Worker medical evaluations and training.

6.2 Lessons Learned

For lessons learned applicable to manual and mechanical material handling, refer to the following Internet address:

http://www-r.llnl.gov/es_and_h/lessons/lessons.shtml

6.3 Other Sources

ANSI B56.11, "Forklift Trucks" (latest edition).

ASME/ANSI B30.2, "Overhead and Gantry Cranes" (latest edition).

National Institute for Occupational Safety and Health, *Work Practices Guide for Manual Lifting*, DHHS 81-122 (1981).

National Institute for Occupational Safety and Health, *Applications Manual for the Revised NIOSH Lifting Equation*, DHHS 94-110 (January 1994).

National Safety Council, *Accident Prevention Manual for Business & Industry—Engineering & Technology*, Chapter 5, "Ergonomics in the Workplace," and Chapter 8, "Manual Handling and Material Storage" (latest edition).